SVP SOCIETY OF VERTEBRATE PALEONTOLOGY
www.vertpaleo.org

Society of Vertebrate Paleontology

SVP Headquarters • 1660 International Drive, Suite 600
McLean, VA 22102, USA
Phone: +1 (301) 634-7024 • Fax: +1 (703) 506-3266
Email: svp@vertpaleo.org • Web: www.vertpaleo.org
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Best Practice Guidelines for Mitigation of Adverse Impacts on Paleontological Resources

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I. Introduction

The Society of Vertebrate Paleontology (**SVP**) strives to promote the preservation and protection of paleontological resources, particularly vertebrate fossils and fossil localities. Mitigation paleontology entails the recovery and conservation of fossils that are threatened by human activities, including ground disturbance, vandalism, and poaching. It is also increasingly used to recover and conserve fossils that are not threatened by human activities but that have been determined to be in danger of destruction by natural forces such as weathering and erosion. In 1991 (along with subsequent updates in 1995, 1996, and 2010), SVP's then-standing Impact Committee developed guidelines for conformable impact mitigation for nonrenewable paleontological resources. However, the guidelines were concerned primarily with paleontological resources on federal, state, county, and city lands in the USA. This document represents efforts made by a working group consisting of SVP members who are professional mitigation paleontologists in collaboration with SVP's Government Affairs Committee and Collections and Repository Committee to expand the scope to be globally applicable with input from paleontologists within the mitigation community and at natural history museums or other repositories and government agencies around the world. Although the best practices presented here are meant as guidelines, especially because they may not necessarily apply to all possible circumstances, SVP expects members to be aware of these universal professional standards as they develop and to provide the Society with feedback to help improve them.

II. Purpose and Need

Mitigation paleontology has resulted in the recovery and preservation of countless scientifically significant fossils worldwide. As land development continues at an ever-increasing pace, the need to conserve fossils impacted by ground disturbance and other human-caused impacts is also growing. The implementation of best practice guidelines helps to ensure the development and application of mitigation paleontology procedures that are consistent with accepted scientific standards in paleontology. The impact mitigation process includes the evaluation of potential impacts and the development of measures to reduce or eliminate adverse impacts to scientifically significant fossils, as well as the implementation of those measures and the conservation of fossils in repositories (including museums) or preservation *in situ*. Best practices in mitigation paleontology establish standard procedures that have and will continue to evolve over time. They have been shown to be successful in maintaining a rigorous scientific standard while promoting integrity and consistency in the mitigation process to accomplish the objective of fossil conservation.

The most immediate benefit of best practice guidelines is seen in jurisdictions with laws and regulations that have existing protections for fossils. These guidelines assist regulators, mitigation paleontologists, and repository staff by promoting regulatory compliance, achieving consistency in the implementation of impact mitigation measures, and establishing scientific standards that achieve the goal of preserving scientifically significant fossils and contextual information for research and education. Furthermore, best practice guidelines should evolve over time and can be used to assist regulators with updates to existing legislation, regulations, ordinances, and policies (legal requirements) to best achieve the preservation of scientifically significant fossils in perpetuity. In jurisdictions either contemplating or in the process of developing legal requirements for impact mitigation, best practice guidelines provide a framework around which these requirements should be established and maintained, promoting a more informed approach to the impact mitigation process.

In jurisdictions that do not implement impact mitigation requirements for fossils, these best practice guidelines provide a starting point for research and avocational fossil collectors, lawmakers, civil servants, and other interested parties to inform decision-makers. Combining these best practice guidelines with examples of successful mitigation projects completed in other jurisdictions can help persuade decision-makers to enact legal requirements that will provide for the mitigation of adverse impacts to fossils in their local jurisdictions. This will result in the recovery and preservation of scientifically significant fossils and associated contextual information that would otherwise be lost to humanity.

III. General Preconditions for the Impact Mitigation Process

Legal requirements governing mitigation paleontology vary across the globe. For jurisdictions that do not have an established regulatory framework and supporting system of repositories and professional paleontologists in place to protect fossils threatened by human activities, including ground disturbance, vandalism, and theft, or natural causes such as weathering and erosion, the following are general preconditions that are recommended to support the development of a mitigation paleontology program:

A. Legal requirements defining and protecting fossils, including criteria for triggering impact mitigation requirements (e.g., project area contains geological units known for containing significant fossils; thresholds for proposed infrastructure total value or capacity). Typically, such criteria include a definition of scientifically significant fossils (see V, Phase 2j). Impact mitigation requirements may also be triggered by the depth and/or volume of ground disturbance.

B. An agency or authority with knowledge of paleontology and regulatory expertise that is responsible for issuing permits to practice mitigation paleontology. The agency or authority should be authorized to require impact mitigation, develop or approve mitigation measures or resource management recommendations, review mitigation reports, ensure permit compliance, verify that fossils recovered during impact mitigation projects are curated in a repository, verify that project owners are in compliance with project conditions of approval, and ensure that best practices in mitigation paleontology are adhered to.

C. A mechanism for determining land ownership or management. Land ownership determines fossil ownership in some countries. In these instances, a determination of land ownership or management authority (if public land) may be necessary to determine paleontological impact mitigation requirements.

D. Criteria for evaluating the potential for adverse impacts on fossils in accordance with project-specific resource management or impact mitigation objectives. The evaluation itself should be conducted by a mitigation paleontologist or an agency or authority with knowledge of mitigation paleontology and applicable legal requirements. The criteria may be based on geologic mapping if the mapping exists at a sufficiently detailed scale to be useful for the area, and/or considers topographic and geomorphologic conditions that are likely to increase the probability of damaging or destroying fossils during a specific ground disturbing action. If a mitigation paleontologist or agency with knowledge of mitigation paleontology is not available, a paleontologist with local expertise can be consulted and provided with a copy of this document. SVP can also be contacted to provide contact information for members with experience in mitigation paleontology.

E. Minimum standards for impact mitigation reports and associated deliverables, including fossil locality forms and geographic information systems (GIS) data.

F. Repositories with the following: A) staff that have paleontological expertise; B) a fossil preparation laboratory and collections storage facility to accept specimens and associated data recovered as the result of impact mitigation projects; and C) ability and commitment to curate specimens and data in perpetuity, ensuring access for further study and educational outreach. The repository approved by the agency or authority should also have curatorial staff, a collections management policy that clearly articulates access policies for scientific research by qualified researchers, and fossil preparation and curation standards for fossils and contextual data that adhere to agency or authority requirements. These standards should be adhered to by mitigation paleontologists submitting collections to the repository and enforced by the agency or authority.

G. For mitigation projects in jurisdictions with established mitigation requirements, especially those projects that are large and/or long-term or with abundant scientifically significant fossils, an agency or authority may develop additional requirements to fund educational and research programs to benefit local citizens. This process could include requirements and guidelines for identifying consulting parties, public involvement, and in-kind (or compensatory) mitigation options if significant fossils are negatively impacted and direct mitigation is not possible.

IV. Qualifications

Personnel engaged in mitigation paleontology must have training and expertise in paleontology and sedimentary geology, experience working around construction equipment (including safety training) and be competent in paleontological fieldwork. Experience with similar geologic units, fossils, and time periods is more important to the successful outcome of a mitigation project than experience in a particular geographic area. However, experience working on specific types of mitigation projects, such as field surveys versus excavation, is also important to ensure a successful outcome. Mitigation paleontological personnel must not take leadership or supervisory roles if their prior project experience or scientific expertise does not match the paleontological scope. A subject matter or situational expert with specialized training and experience with a particular type of fossil, collection technique, geological deposit, or project impact should be utilized when the need arises. For example, if a paleontological principal investigator's experience has been limited to marine invertebrates, a subject matter expert should be used for projects with terrestrial vertebrates.

Paleontological mitigation work is generally conducted by four categories of personnel with different levels of expertise and responsibility: 1) laboratory technician, 2) field paleontologist, 3) paleontological field supervisor, and 4) paleontological principal investigator. It must be noted that these personnel categories are solely for the purpose of this document and do not reflect a broader position by SVP on how to categorize professional roles in the wider science of paleontology. The field paleontologist and laboratory technician positions are not hierarchical, but rather the former is specialized for field responsibilities whereas the latter is specialized for laboratory responsibilities. The field paleontologist is an introductory level position, needing further training and/or experience to achieve the level of professional mitigation paleontologist. Paleontological principal investigators and field supervisors are both considered to be qualified professional mitigation paleontologists. The following is a list of recommended minimum qualifications for each personnel category based largely on Murphey et al. (2019):

Category 1: Laboratory Technician. Someone with demonstrated experience in fossil preparation who may have academic training (college or university degree) with an emphasis in paleontology. This includes past professional experience in a laboratory that prepares fossil vertebrates, invertebrates, and plants for curation and exhibition; knowledge of laboratory techniques applicable to a diversity of fossil types; familiarity with the use of archival chemicals and fossil preparation tools; and a basic understanding of paleontological resource conservation. Field paleontologists and paleontological field supervisors may assist with laboratory-related tasks depending upon their abilities and experience level but should recognize that laboratory fossil preparation requires a specialized skill set.

Category 2: Field Paleontologist. Someone with academic training (college or university degree) with an emphasis in paleontology or demonstrated equivalent experience. Academic training as defined herein must include completed basic coursework in paleontology, geology, and biology. Equivalent experience is defined as a minimum of two years of cumulative professional or non-professional work in laboratory preparation, curation, and/or fieldwork related to paleontology, as well as documented knowledge of the discipline of paleontology. The field paleontologist must be able to safely find, recover, and identify to a basic level, fossils discovered in undisturbed settings as well as in active excavations at construction sites. The field paleontologist must also be able to identify and describe sedimentary rocks and stratigraphic relationships and be able to effectively communicate information about fossil discoveries, using photographs and written descriptions, to the paleontological principal investigator and/or field supervisor. Individuals who lack sufficient experience to be qualified as field paleontologists can gain the necessary experience by working alongside field paleontologists, field supervisors, or principal investigators.

Category 3: Paleontological Field Supervisor. Someone with the same qualifications as Field Paleontologist and an advanced academic degree (Master's or Ph.D.) with an emphasis in paleontology or demonstrated equivalent professional experience and one year (or 25 completed mitigation projects) of experience with paleontological mitigation, working under the direct supervision of a qualified professional mitigation paleontologist, from project initiation to fossil discovery to fossil collection, laboratory preparation, fossil inventory, specimen identification, and repository curation. Equivalent experience to a graduate degree is defined herein as a minimum of three years (or 75 completed mitigation projects) of experience with paleontological mitigation from project initiation to fossil discovery to fossil collection, laboratory preparation, fossil inventory, specimen identification, and curation under the supervision of a principal investigator. The field supervisor must be able to manage field paleontologists and fossil recoveries, communicate with project personnel, evaluate the scientific significance of fossils, and make decisions regarding impact mitigation. The field supervisor must be able to ensure field notes and observations are complete, study area stratigraphy is documented, and fossil localities are accurately indicated on measured stratigraphic sections.

Category 4: Paleontological Principal Investigator. Someone with an advanced degree (Master's or Ph.D.) with an emphasis in paleontology plus a minimum of two years (or 50 completed mitigation projects) of demonstrated professional experience and competency with paleontological resource mitigation projects at the level of field supervisor, under the direct supervision of a principal investigator. This experience should include project initiation, fossil discovery and collection, laboratory preparation, fossil inventory, specimen identification, and repository curation. The principal investigator must be able to manage field paleontologists and fossil recoveries, communicate with project personnel, evaluate the scientific significance of fossils, and make decisions regarding impact mitigation. The principal investigator must also be able to ensure field notes and other observations are complete, study area stratigraphy is documented, and fossil localities are accurately indicated on measured stratigraphic sections. Additionally, the principal investigator must have a working knowledge of how fossils and their associated data are used in conducting and publishing professional paleontological research (such as demonstrated by having a record of peer-reviewed paleontological publications) and should participate in professional scientific organizations. The principal investigator must have experience evaluating the significance of unearthed fossils, obtaining necessary permits, and preparing and submitting required progress and final mitigation reports. The principal investigator must have project management experience and knowledge of legal requirements that apply to all aspects of mitigation paleontology. The principal investigator must also be able to evaluate the qualifications of field supervisors and field paleontologists and make responsible project staffing decisions.

V. Process of Mitigation Paleontology

Mitigation paleontology is a process that consists of nine different phases that proceed sequentially depending upon the results of the prior phase, although in some instances steps in the process may be bypassed or implemented concurrently. In general, proposed surface disturbing actions that have a higher potential for damaging or destroying scientifically significant fossils involve a larger level of effort to mitigate adverse impacts.

The distinction between a project area and a study area is important in mitigation paleontology. A project area consists of the external boundary of the project that is triggering the impact mitigation process. The study area is the geographic area where impact mitigation is needed: e.g., an area of proposed ground disturbance within the project area plus a buffer or the entire project area plus a buffer. In some cases, the project area and study area are the same and, in some cases, no buffer is needed (e.g., see V, Phase 2a). Another important distinction is a survey area, which may be equivalent to the study area or a subsection thereof that has been determined to have a greater potential for impacts to surface paleontological resources and therefore has been selected for a pedestrian survey. The impact mitigation process includes the following nine phases, seven of which are shown in Figure 1:

Phase 1: Permitting. Permits to conduct fieldwork or collect fossils are required in certain countries, states, provinces, and/or other jurisdictions, such as lands managed by government agencies. A repository curation agreement may be a prerequisite for obtaining a permit in some jurisdictions. The curation agreement, or discussions with a repository prior to receiving an agreement should provide information that includes its scope of collections, pre-curation requirements, and associated curation fees. Permits should be in place or be obtained prior to the beginning of any fieldwork. In some cases, a permit may be required to obtain confidential previously recorded fossil locality data. When working on indigenous lands, respect all policies and cultural practices to reduce impacts.

Phase 2: Paleontological Resource Impact Evaluation. The initial investigative phase in the mitigation process involves analyzing existing data to evaluate the potential for a project to impact scientifically significant fossils. There are 12 elements of the data analysis:

a. Preliminary Assessment. This step involves a preliminary study of the geology, geomorphology, and topography of the study area and should be completed by a qualified professional mitigation paleontologist, or a resource management professional in the applicable regulatory agency. Several predictive models that are based on the close association between fossils and the geologic units (formations, members, etc.) which contain them have been developed. These utilize published geologic mapping to depict the distribution of potentially fossil-bearing geologic units. The Fossil Prediction Map System (**FPMS**) is recommended here (Table 1). The FPMS is a resource-management tool based on two basic facts of paleontology: 1) fossil occurrences are closely tied to the geologic units (i.e., formations, members, or beds) that contain them; and 2) the presence of fossils can be broadly predicted from the distribution of geologic units at or near the ground surface. This predictive schema classifies geologic units on the relative abundance of scientifically significant vertebrate, invertebrate, or plant fossils, with a higher classification number indicating a higher potential for scientifically significant fossils to be contained within a geologic unit (or "paleontological potential"). Mapping with FPMS assignments attributed to geologic unit polygons is a useful approach for evaluating the potential of geologic units to contain scientifically significant fossils in specific geographic locations. In lieu of, or in addition to, available geologic mapping, the topography and amount of exposed sedimentary bedrock as observed in the study area can be used as a predictor of where surface fossils will occur, the presence of which can in turn predict the presence of subsurface fossils. The result of the preliminary evaluation is to determine whether a proposed project has the potential to damage or destroy scientifically significant surface and/or subsurface fossils and to appropriately trigger the additional steps of the existing data analysis.

b. Surface and Subsurface Ground Disturbance. If the study area has the potential to contain scientifically significant fossils, or its paleontological potential is unknown, the type and dimensions of proposed ground disturbance must be evaluated to determine if ground-disturbing activities will or will not actually have the potential to impact paleontological resources. This element of the analysis process generally relies on reviews of project design plans, construction equipment descriptions, geotechnical studies, and preliminary disturbance estimates.

c. Laws, Regulations, Ordinances, and Policies. Legal requirements pertaining to impacts on fossils and other resources in the study area must be adhered to.

d. Resource Management or Impact Mitigation Objectives. Understand the resource management objective of the mitigation project before beginning work as the objectives may vary by project. For example, an objective may be to inventory fossils in a study area and develop a management plan to monitor observed fossils. Another objective may be to recover scientifically significant fossils that are unearthed during a construction project and place them in a repository.

e. Geologic Map Review. This review is more comprehensive than the preliminary review (see Phase 2a). The most detailed (largest scale) maps available should be utilized to understand the geology of the study area and the areal and likely subsurface distribution of individual geologic units.

f. Repository/Agency Record Search. Complete a paleontological record search at repositories and/or agencies that archive paleontological data for the study area to determine the number of previously recorded fossil localities per geologic unit present within the area, and to determine the abundance of fossil localities within 1–4 km (or as otherwise specified by an agency) of the study area in the same geologic units. Knowing the locations of previously recorded fossil localities is necessary to ensure that these localities can be reevaluated and that impacts on documented fossil-bearing horizons can be assessed and mitigated, if necessary. The size of the record search buffer (land outside the study area) is variable and may be defined by an agency or based on the judgment of the qualified professional mitigation paleontologist. Capturing locality data outside of the study area can provide a more regional understanding of the overall paleontological potential for the geologic units that occur within the study area. This is important because the lack of recorded localities within a study area may not be indicative of a lack of fossils, but rather may reflect a lack of prior fieldwork. Column 1 of Table 2 lists the dataset that would ideally be provided by the repository and/or agency providing the records search results. However, at a minimum, the data received for each fossil locality should include geographic location, geologic unit, and recovered taxa. Certain types of data, such as fossil locality coordinates and project location, may be sensitive and confidential. Guidance related to the confidentiality of vertebrate fossil locality data can be found in SVP's Best Practice Guidelines for Repositing and Disseminating Contextual Data Associated with Vertebrate Fossils (https://vertpaleo.org/wp-content/uploads/2021/01/SVP-Paleo-Best-Practice-Guidlines-2nd-Ed.pdf). Repositories and/or agencies may charge a fee to provide these data.

g. Literature Review. Published scientific literature and unpublished technical reports relevant to the study area and the geologic units within it must be reviewed for general information about past paleontological work, academic or otherwise, and fossil localities (typically older, sometimes historic) that are not captured in the record search. Such reviews also provide a basis for evaluating the scientific significance and research value of the fossils known to occur in specific geologic units.

h. Local Expertise. If applicable, consult with professional paleontologists as well as avocational fossil collectors and nearby residents who are familiar with the study area to supplement the information gathered from the geologic map review, the literature search, and record search results. For example, a paleontologist with experience working in a specific geologic unit or geographic area can share knowledge that could streamline the field survey and result in a greater number of fossil discoveries.

i. Aerial Image Review. Conduct an aerial image review to determine the locations of potentially fossiliferous exposures of bedrock or surficial deposits in the study area to assist with the evaluation of paleontological potential and to plan the field survey or monitoring effort. The aerial image review is also useful for mapping access routes to the study area.

j. Define Scientific Significance. The need to determine the scientific significance of fossils is fundamental in mitigation paleontology. For example, it is critical in assigning paleontological potential (Table 1) to geologic units within a study area during preparation of paleontological resource impact evaluations, it is useful when evaluating recorded fossil localities (Table 3), and it is essential during development and implementation of mitigation recommendations (Table 4). Scientific significance can be difficult to define because it is often determined by individual researchers based on their area of expertise. Unless specifically required to use other criteria, the use of the criteria developed by Scott and Springer (2003) as shown in Table 5 is recommended because it has been found to be effective for a broad spectrum of paleontological resource management purposes.

k. Data Synthesis and Recommendations. Compile the data gathered during the previous steps and develop recommendations for future paleontological work for review by the agency, authority, and project owner. Basic recommendations include no further paleontological work, unpredicted discovery notification and locality exploration stipulations, completion of a paleontological survey (collection or non-collection resource inventory), preparation of a Paleontological Resource Monitoring and Mitigation Plan, and/or monitoring of ground-disturbing activities during construction (Table 4).

l. Report. If required, present the results of the existing data analysis in a Paleontological Resource Impact Evaluation Report (see Phase 7, Table 6).

Phase 3: Field Data Collection. The collection of accurate field data is one of the most complex aspects of mitigation paleontology. The challenge is to design and implement a data recordation protocol that is accurate, efficient, adaptable, and intuitive.

a. There are two categories of field data in mitigation paleontology: paleontological data and project data. Paleontological data document the locations and types of fossils and their geologic context. These data provide the contextual information necessary to maintain the research value of recovered fossils. Project data include daily details of the work performed and other project-related information.

b. A field data collection protocol should be easy for field crew members to learn, readily comparable between field crew members, and designed for use on all sizes and types of projects. Recommended types of field forms and data fields are provided in Table 2.

c. In advance of fieldwork, contact project owners, land management agencies, and the repository to ensure planned data collection meets their standards and requirements. These data include topographic, lithologic, and stratigraphic information on observed geologic units; and if applicable, paleontological locality information and how the project is anticipated to impact the fossils in the study area (see Table 2).

d. All fossil localities must be documented (see Table 2, Column 1), regardless of their scientific significance or whether fossils are ultimately collected.

e. Ensure that all field data are recorded as accurately and precisely as possible given available technology.

f. Estimating the surficial and subsurface extent of bedrock and the topographic relief in an overall study area is useful for making decisions about future mitigation work in the study area. For larger projects, subdividing the study area into smaller geographic subareas (northwestern corner, pipeline or highway station numbers, highway kilometer range, cross streets) is useful to make these estimates meaningful.

g. All areas that were physically surveyed and/or monitored (e.g., survey area, monitoring area), as well as those that were visually cleared while conducting a pedestrian survey or cleared through the impact evaluation process must be documented regardless of whether fossils were found. Negative data are essential for managing paleontological resources.

Phase 4: Field Surveys. The purpose of a field survey (collection or non-collection) is to locate and document exposed fossils and potentially fossiliferous geologic units within a study area, to re-locate and evaluate previously recorded fossil localities, and to document areas that have the potential to produce subsurface fossils during project construction.

a. Prepare a survey team for fieldwork by providing them with existing data and key publications, maps, construction design plans, appropriate field equipment, safety training, survey schedules, survey area priorities, paleontological resource impact evaluation report (if one was previously prepared), field survey plan (if one was prepared), and chain-of-command structure for notification of fossil discoveries.

b. Ensure that the survey team has copies of necessary access authorizations and permits and that these permissions remain valid during the duration of the fieldwork.

c. All exposures of geologic units with high and very high potential within a study area must be surveyed. Exposures of geologic units with moderate potential should be subject to at least a partial survey. Exposures of geologic units with unknown potential may be entirely surveyed or subject to a partial survey to attempt to determine the actual paleontological potential. In general, the survey level of effort may be increased or decreased as appropriate based on the number of fossil discoveries made or on the lack thereof.

d. The ground surface cannot be surveyed if it is covered with snow or construction debris. Nor can it be surveyed if it is flooded or too muddy prior to initiating field surveys.

e. Field surveys must be conducted on foot rather than in a vehicle to maximize the potential for fossil discoveries. Fossils and sometimes entire fossil-bearing exposures can be overlooked when the person conducting the survey fails to survey on foot.

f. The use of archaeological field techniques in mitigation paleontology is discouraged (e.g., walking transects and shovel testing) because they have not been shown to be effective in paleontology.

g. For scientifically significant fossil localities discovered during field surveys, there are typically three standard mitigation options: collection, deferred collection, and avoidance. Phase 6 below provides the recommended fossil recovery process, including initial fossil locality evaluation.

h. In most cases, the collection of scientifically significant fossils in a study area is the recommended impact mitigation approach. There are certain types of projects that can be modified to avoid fossil localities, but this may be more expensive and disruptive to the project design than fossil collection. When possible and cost-effective, fossil collection rather than avoidance of the locality should be recommended to a project owner or agency for the greater goal of fossil conservation. In cases where paleontological resources cannot be collected (e.g., *in situ* tracks) the most significant ones should be duplicated physically (e.g., molds or casts) and/or digitally (e.g., photogrammetry, LIDAR, and 3D scanning) following the data standards of the repository and agency or authority.

i. If avoidance is the preferred option, then an alternate route or project location that avoids scientifically significant fossil localities should be surveyed.

j. There are two different types of field surveys. Block surveys are often employed at the programmatic level, where surveying the entire project area may be the best approach for larger projects with unknown infrastructure locations (e.g., wind turbine locations that have not yet been sited). Block surveys also provide greater flexibility for avoiding scientifically significant fossils. Infrastructure-specific surveys are targeted to planned locations of specific project elements with anticipated ground disturbance within a larger project area (e.g., wind turbine pads, or highway corridor), and may include a survey buffer.

k. Extensive fossil discoveries are those that are not anticipated and should typically be considered outside of the scope of fossil collection related to field surveys (or construction monitoring: see Phase 5). An example would include the discovery of a dinosaur or large mammal skeleton, or a multi-individual bone bed. If discovered, extensive localities are typically avoided to keep the project on schedule and within budget. If an extensive locality cannot be avoided, a locality-specific mitigation plan must be prepared. Certain extensive localities (e.g., dinosaur track site, large bone bed, fossil forest) are typically too large or complex to collect and are often left in place to be preserved and managed *in situ*. Regardless of whether the discovered localities are avoided, or the fossils are recovered, consultation with the applicable agency or authority and a repository that may have an interest in the discovery is recommended as part of the impact mitigation process.

l. Prepare a paleontological field survey report (see Phase 7, Table 6).

Phase 5. Monitoring of Ground Disturbance. There is no academic training available for the basic skills specific to paleontological resource construction monitoring. On-the-job training is the only option. The term monitor refers to a field paleontologist, field supervisor, or principal investigator who is performing the construction monitoring. The purpose of monitoring is to discover and reduce damage or destruction (i.e., minimize adverse impacts) to scientifically significant fossils that are unearthed during construction. Monitoring entails conducting inspections of excavation sidewalls, graded surfaces, trenches, and spoils piles for evidence of fossils exposed by excavations, often on surfaces that are partially obscured by particulate and rock debris.

a. Monitoring should be a mitigation requirement when construction will disturb geologic units that contain scientifically significant fossils. Full-time monitoring is generally recommended for geologic units with high and very high potential, whereas part-time monitoring is usually recommended for geologic units with moderate potential. Geologic units with unknown potential may be monitored full-time initially, but then decreased to part-time or suspended completely depending on observations made during monitoring.

b. Some types of construction equipment (e.g., auger with a bit that is less than 40 cm in diameter, certain types of ditching machines, tunnel-boring machines) pulverize rock and destroy fossils before there is an opportunity to recover them. Some construction methods (e.g., excavation with a hydrovac truck) are closed-loop systems that do not produce observable spoils. Monitoring is not recommended for these activities. Spot-checking for smaller fossils may be appropriate for augering and ditching machines that yield fragments of rock large enough to preserve fossils.

c. As with field surveys (see Phase 4a), monitors should be provided with all necessary project information prior to beginning work. This may include a copy of the Paleontological Resource Monitoring and Mitigation Plan (if one was prepared; see Table 6, Column 4), but at a minimum should include copies (or access to digital versions) of grading plans and relevant geologic and paleontological reports.

d. Monitors must strictly adhere to all project safety requirements, particularly with regard to working around heavy equipment and entering project excavations. As a rule, monitors should never do anything that they feel is unsafe.

e. Prior to project initiation, construction personnel should be made aware of the known paleontological potential of the site and the types of fossils that could be unearthed during construction. A pre-construction training is recommended, during which construction workers should be informed of notification procedures in the event of an inadvertent fossil discovery in the absence of a qualified professional mitigation paleontologist or field paleontologist. If such a discovery is made, the potential fossil must be left in place, and construction activities should be diverted to a minimum distance of 15 m until a qualified professional mitigation paleontologist can evaluate the discovery.

f. If the opportunity is available, monitors should do a final surface check immediately prior to the commencement of ground-disturbing activities to ensure that no scientifically significant fossils are exposed on the surface of the site.

g. When equipment is not running, monitors should use the opportunity to examine the excavation, document the stratigraphy, and explore spoils piles.

h. Monitoring cannot succeed if monitors are not within visual range of the active excavation where they have access to freshly disturbed rock, ideally 1.5 to 6 m, but no greater than 9 m, and even at that distance fossils may not be visible if they are small.

i. Regardless of whether fossils are found, monitors should document the stratigraphy of the study area during the normal course of monitoring so that if fossils are discovered they can be readily located within the stratigraphic section. In addition, this work provides information critical to interpreting the local paleontological record, as well as facies relationships and depositional environments.

j. The paleontological principal investigator should have the ability to increase or decrease the monitoring level of effort based on operational factors, including the preservational potential of the observed strata and the number of fossil localities that are being discovered during construction.

k. When a potential scientifically significant fossil is discovered, the monitor should immediately alert the equipment operator to temporarily halt work, and after an initial evaluation, make any other project-specific notifications. The fossil discovery site should be cordoned off if the fossil(s) cannot be documented and recovered rapidly, and additional personnel mobilized as needed to support monitoring and locality exploration and evaluation. Construction should be directed away from the locality, ideally to a minimum distance of 6 m, although the buffer size should be increased for safety reasons or if the monitor determines that the locality may be more extensive (see Phase 6 below for the recommended fossil recovery process, including initial fossil evaluation).

l. Prepare a paleontological monitoring report (see Phase 7 below, Table 6).

Phase 6: Fossil Specimen Recovery (Locality Evaluation and Fossil Recovery to Pre-Curation). Fossil recovery activities for mitigation paleontology projects can be separated into two categories: fossils that are collected during field surveys and fossils that are collected during construction monitoring projects. Fossil recovery also includes laboratory fossil preparation, fossil identification, and pre-curation. Although both recovery categories have many similarities in field procedures, they also have some important differences primarily related to impact mitigation. One of the most critical differences between the two is the amount of time available to complete fossil recovery operations. The fossil recovery process generally has five phases: evaluation, exploration, excavation, transportation, and laboratory (Table 3).

a. For all scientifically significant fossil localities, recovery techniques appropriate to the size and preservation of the fossil must be used. All field paleontologists must be knowledgeable about fossil recovery and sampling techniques and properly equipped. Medium- to large-sized specimens or groups of specimens should be excavated encased in a block of sedimentary matrix and jacketed to provide stability to expedite fossil removal and minimize construction delays. Construction equipment can be used to facilitate the fossil excavation process so long as the equipment does not come into direct contact with the fossil(s) and can also be used to lift heavy jackets onto vehicles for transport off-site. All locality data must be recorded (see Table 2, Column 1), and containers and jackets must be properly labeled and documented prior to removal from the project site.

b. Wet screen washing of sedimentary matrix for microscopic fossils (vertebrate, invertebrate, and plant) is an important procedure that has been demonstrated to yield results unobtainable via any other means and can produce significant increases in both the taxonomic diversity and specimen numbers from a fossil locality. Smaller matrix samples may be justified either based on conditions in the field (e.g., limited volume of matrix available for sampling) or scientific analysis (e.g., rarefaction analysis).

c. Paleontological repositories may require fossils to be fully prepared prior to their arrival. In these cases, the preparation staff at the repository should be consulted to provide guidance to ensure that the fossils are prepared according to the repository's conservation standards.

d. Fossils must be properly prepared to the point of curation in accordance with repository protocols and applicable legal requirements. Pre-curation work must also include the preparation of a fossil catalog, digital assembly of field and laboratory data, and labeling and packaging fossils in preparation for transport to a repository.

e. From the time fossils arrive at a preparation laboratory if different from the repository, a "chain of custody" must be ensured so that the fossils and their contextual data are properly and securely stored. During transportation to a repository, fossils must be accompanied by proper documentation (permit, curation agreement, etc.).

Phase 7: Data Management and Reporting. Data management strategies should emphasize streamlined data entry, accuracy, proper metadata recording, regular backup, and efficient retrieval of information. Project reporting requirements vary by agency, and final project reports should meet or exceed agency standards. If there is no agency involvement or the agency involved does not have established standards, then the best practices presented here should be followed.

a. All paleontological reports, including sections of larger documents containing paleontological analyses (e.g., environmental planning documents), should be written by, or at a minimum, reviewed by, a paleontological principal investigator.

b. Table 6 summarizes the five standard types of impact mitigation documents: impact evaluation reports, field survey reports, monitoring reports, impact mitigation plans, and environmental planning documents.

c. Every impact mitigation program should be designed around a theoretical framework that places it in a scientific context, and that facilitates later research activities. The framework should serve as a road map that guides the implementation of the mitigation work including the development of the threshold criteria for scientific significance, which fossils are collected, how they are collected, and the types of associated data that are collected. The theoretical framework should be considered when developing project scopes of work and budgets, and it should be presented in paleontological resource impact mitigation evaluation reports and paleontological resource monitoring and mitigation plans.

d. All fossils, regardless of significance, must be documented in field notes and photographs and on stratigraphic sections. All project reports should include a list of all fossils documented during the project and a discussion of their scientific significance or lack thereof.

e. All field survey and monitoring reports must include documentation of areas that were surveyed or monitored, regardless of whether fossils were found.

f. All paleontological survey and monitoring reports must include the results of the existing data analysis if it was not included in a prior stand-alone project report. Monitoring and mitigation plans must be based on an existing data analysis and/or field survey and steps must be taken to ensure that these plans provide detailed recommendations on monitoring locations and procedures, and fossil recovery procedures.

g. Mitigation recommendations should be developed by a paleontological principal investigator working closely with the agency (if any), repository, and project owner while taking into account the paleontological research potential of the study area. Effective impact mitigation accomplishes project objectives while meeting regulatory requirements and preserving (reducing adverse impacts to) fossils. Standard impact mitigation recommendations are listed in Table 4.

Phase 8: Repository Curation. This is the final element in the impact mitigation process when mitigation-generated fossil collections are deposited at the selected repository. At repositories, institutional fossil locality numbers are assigned, individual specimens or specimen ‘lots’ are cataloged with unique specimen numbers, field data are entered into computerized databases, and fossil specimens are housed in cabinets or on storage shelves. Some general guidelines concerning repository curation include:

a. Mitigation paleontologists must ensure that all scientifically significant fossils collected during mitigation projects are curated at a museum/repository to avoid the accumulation of “orphan collections.”

b. Mitigation paleontologists should coordinate with repository curatorial staff and relevant agencies (if applicable) in advance of fossil collection to determine the types and amounts of fossils that may be curated, the level of preparation and types of documentation expected, and delivery timeframes. The mitigation paleontologist is responsible for ensuring that the fossil collection adheres to repository curatorial and data management policies following repository and agency guidance when applicable.

c. Mitigation paleontologists should only reposit fossils that have scientific significance, and that fall within the scope of the repository's collections as determined by that repository. In addition to research purposes, repositories may accession specimens specifically for inclusion in a teaching collection, for use in fossil preparation instruction, or for exhibition. However, such decisions are the responsibility of the repository and/or agency or authority.

d. Fossil collections from the same locality should not be divided between different repositories unless necessary to meet permitting or curation requirements.

e. The mitigation paleontologist or project owner is typically responsible for paying any fees levied by the repository for curation and permanent storage.

f. If a repository is not willing or able to accession fossils that meet scientific significance criteria (Table 5 or as otherwise defined), it is the responsibility of the mitigation paleontologist or project owner to find another repository.

g. If after collection and laboratory preparation the repository declines to accession a fossil collection because they do not meet the repository's scientific significance criteria and/or do not fall within its scientific mission, the mitigation paleontologist should make a good faith effort to transfer the fossil collection to an educational institution for non-commercial teaching purposes with agency approval as applicable.

Phase 9. Business Ethics and Scientific Rigor. Ethical standards in mitigation paleontology require that individual qualified professional mitigation paleontologists place the purpose of impact mitigation—to preserve and minimize adverse impacts to scientifically significant fossils—at the forefront of their business decisions. Adhering to rigorous scientific and professional standards and following best practices is the only way to ensure that such decisions are ethical. Unethical business practices employed by a single practitioner reflect on the entire profession of mitigation paleontology. Practices to follow include the following:

a. When scoping and budgeting mitigation projects, ensure that all decisions are made in a manner that prioritizes the intrinsic scientific value, research potential, and long-term preservation of fossils.

b. If there is a high likelihood that fossils will be found during a project, incorporate this factor into the scope of work and budget. Where applicable, this must include realistic curation fee estimates that have been clarified with applicable repositories. If there is a low likelihood, a negative findings assumption may be appropriate in developing the scope of work and budget.

c. In cases of very low or no paleontological potential, recommend to the agency and/or project owner that impact mitigation may not be necessary. In some cases, a paleontological resource impact evaluation may be required to formally document this recommendation.

Overstating the potential to find fossils to establish or expand a business opportunity is not in the best interest of the profession.

d. Ensure that all mitigation work is properly completed and that all scientifically significant fossils and contextual data are properly collected, prepared, identified, and transferred to a repository along with copies of all final survey and construction monitoring reports.

e. Employ only qualified professional mitigation paleontologists to do unsupervised impact mitigation work.

f. Recognizing the paleobiodiversity of the fossil record, utilize subject matter experts to ensure that fossils recovered during the impact mitigation process are accurately and properly identified to the lowest reasonable taxonomic level required for curation.

g. Cite, but never plagiarize, previous paleontological mitigation reports and any other pertinent sources of scientific information or data. Never falsify findings or reports.

VI. References

Murphey, P. C., G. E. Knauss, L. H. Fisk, T.A. Deméré, and R. E. Reynolds. 2019. Best practices in mitigation paleontology. Proceedings of the San Diego Society of Natural History 47:1–43.

Scott, E., and K. Springer. 2003. CEQA and fossil preservation in California. Environmental Monitor, Association of Environmental Professionals. 9 pp.

Figure 1. Paleontological Resource Impact Mitigation Process Flow Chart.

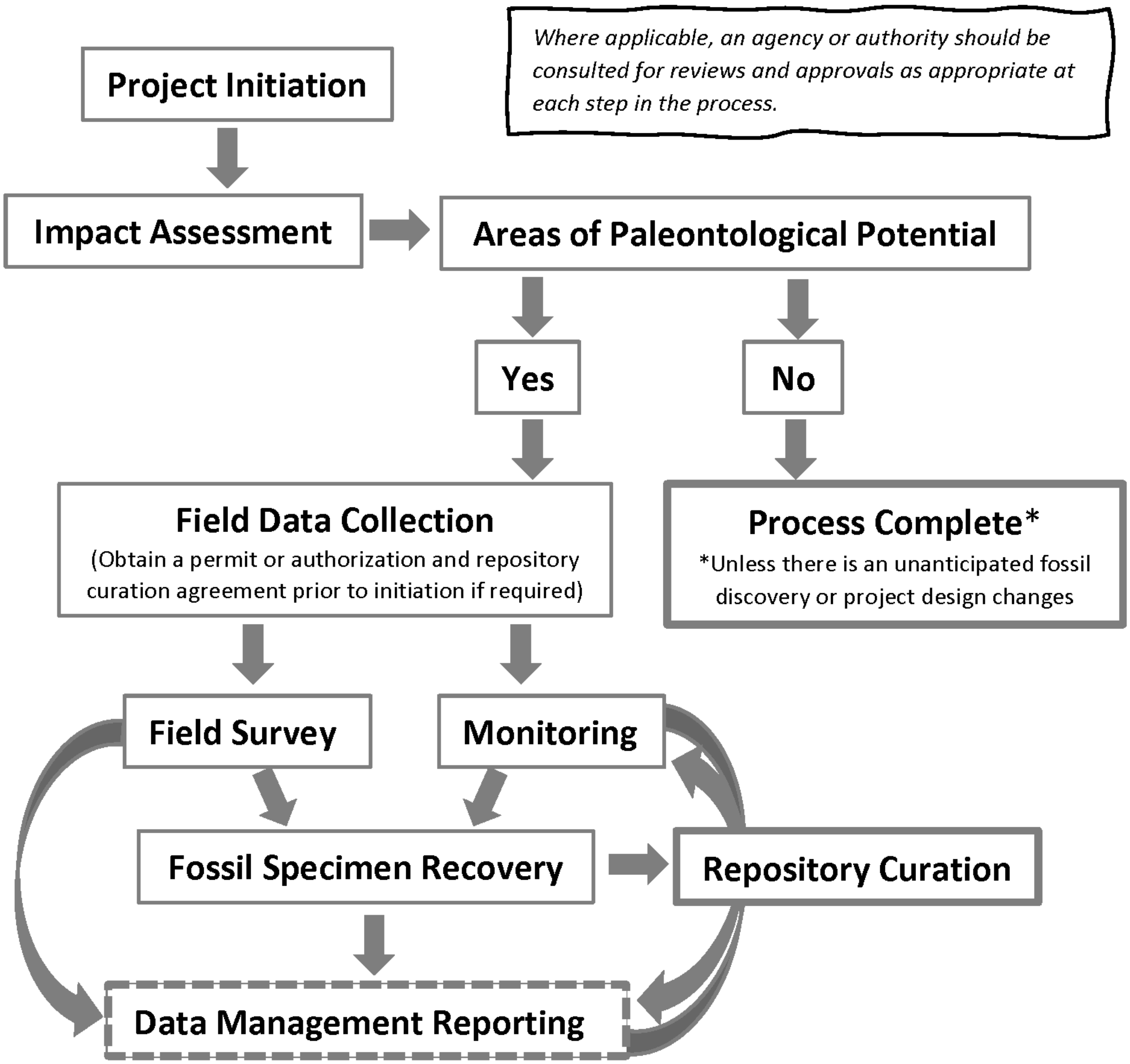

Table 1. Fossil Prediction Map System (FPMS).

FPMS Designation	Assignment Criteria Guidelines and Management Summary
5 = Very high Potential	Highly fossiliferous geologic units that consistently and predictably preserve scientifically significant fossils.
	Management concern is very high. Paleontological resource impact evaluations and field surveys by a professional mitigation paleontologist are typically recommended prior to the proposed activity and full-time monitoring may be recommended during ground-disturbing activities in previously undisturbed geologic units, depending on the type and amount of disturbance. Scientifically significant fossils should be collected or avoided by the proposed project.
4 = High Potential	Highly fossiliferous geologic units that preserve scientifically significant fossils, but their concentrations vary and are less predictable than 5.
	Management concern is high. Paleontological resource impact evaluations and field surveys by a professional mitigation paleontologist are typically recommended prior to the proposed activity and full-time or part-time monitoring may be recommended during ground-disturbing activities in previously undisturbed geologic units, depending on the type and amount of disturbance. Scientifically significant fossils should be collected or avoided by the proposed project.
3 = Moderate Potential	Fossiliferous geologic units that are often marine in origin and in which fossils may be common, but scientifically significant fossils are isolated or sparse.
	Management concern is moderate. Paleontological resource impact evaluations are recommended. Based on the results, field surveys by a professional mitigation paleontologist may be recommended prior to the proposed activity and full- or part-time monitoring may be recommended during ground-disturbing activities in previously undisturbed geologic units, depending on the type and amount of disturbance. Scientifically significant fossils should be collected or avoided by the proposed project.
2 = Low Potential	Geologic units that are not likely to preserve fossils, including sedimentary deposits that are generally younger than 11,700 years before present, older sedimentary units that only rarely preserve fossils, or units that exhibit physical and chemical alteration (diagenetic changes) that make fossil preservation unlikely.
	Management concern is generally low. Paleontological resource impact evaluations, surveys, and monitoring are not typically recommended except in rare situations in which isolated scientifically significant fossils are known to be present in the study area.
1 = Very Low Potential	Geologic units that are not likely to contain recognizable fossils including Precambrian units and units that are igneous or metamorphic, excluding air-fall and reworked volcanic ash.
	Management concerns are very low. Impact mitigation is unlikely to be recommended except in rare circumstances.

FPMS Designation	**Assignment Criteria Guidelines and Management Summary**
U = Unknown Potential	Geologic units that cannot be assigned an informed FPMS designation. This includes units that have not been subject to prior field surveys but that contain lithologies or preserve depositional settings that are known to be conducive to fossil preservation, units that have not been published in the scientific literature, and units in which reports of fossils have not been verified.
	Management concern is medium to high until a provisional designation is made. Lacking other information, field surveys (entire study area or portion thereof for testing) are normally recommended, especially prior to authorizing a ground-disturbing activity. Based on the survey results, monitoring may be recommended during ground-disturbing activities in previously undisturbed geologic units. Any scientifically significant fossils that are discovered should be collected or avoided by the project.
I = Ice or Snow	Mapped geographic areas where underlying geology is obscured by ice or snow. Predictive potential for fossils is low, but when these areas appear on geologic maps or in GIS data, they may be useful for developing mitigation strategies or management recommendations for a larger analysis area that extends beyond the ice or snow.
	Although fossils may be preserved in glacial ice, management concerns are generally low, and impact mitigation is only recommended where fossils are known or may be present such as at the foot of a melting glacier.
W = Water	Mapped geographic area where underlying geology is obscured by water.
	No predictive potential for fossils, but when these areas appear on geologic maps or in GIS data, they may be useful for developing mitigation strategies or management recommendations for a larger analysis area that extends beyond the water or in projects in which the water is being drained. May need to consider the FPMS designation of the underlying geologic units.
	Management concerns are usually negligible or not applicable. Impact mitigation is unlikely to be necessary except in rare circumstances such as along the waterline (or shore).

Table 2. Recommended types of field forms and minimal data fields. Gray-shaded fields represent repeated subparts of a form for recording successive stratigraphic units and photographs. Asterisks denote data that could be added during field data post-processing.

Fossil Locality Log	**Monitoring Area Log**	**Survey Area Log**	**Stratigraphic Log**	**Photographic Log**
Locality number and/or name	Monitor Name	Surveyor Name	Recorder Name	Photographer
Date	Date	Date	Date	Date
Project number and/or name	Project number and/or name	Project number and/or name	Project number and/or name	Project number and/or name
*Legal location, county, state, province, country, etc.	Arrival and Departure Times	Survey Area Name (whole survey area or subdivision thereof if needed for project)	Infrastructure Name (e.g., Panama Canal)	Photograph Number
Geographic coordinates with datum (e.g., UTM NAD83 Zone 13, Latitude/Longitude NAD27)	Monitoring Area Name (e.g., km 10-20 of Highway M5)	Infrastructure Name (e.g., Panama Canal)	Unit++	*Location Reference (e.g., station number, fossil locality number, etc.)
Found By	Infrastructure Name (e.g., Panama Canal)	Infrastructure Type (e.g., gas pipeline)	Thickness	Direction/Bearing
*Survey or Monitoring Area Name (whole survey or monitoring area or subdivision thereof if needed for project)	Infrastructure Type (e.g., gas pipeline)	Managing Authority/Owner of Fossils	Rock Type	Photograph Description
*Managing Authority/Owner of Fossils	Managing Authority/Owner of Fossils	Legal location, county, state, province, country, etc.	Color Fresh	
Location Description (e.g., Lyme Regis, 1.7 km east of Mary Anning's grave site on the beach)	Legal location, county, state, province, country, etc.	Geographic coordinates (e.g., UTM or Lat/Long)	Color Weathered	
Topography (e.g., base of cliff)	Geographic coordinates	Survey Type (pedestrian,	Texture	

	(e.g., UTM or Lat/Long, points or polygons, etc.)	visual, aerial)		
Geologic Unit (e.g., Group, Formation, Member, etc.)	Weather Conditions	Survey Start and Stop	Grain Size	
Stratigraphic Position	Safety Concerns	Topography	Sorting	
Lithology	Equipment (e.g., bulldozer, scraper, ditching machine, vibroseis truck, etc.)	Amount and Approximate Locations of Bedrock Exposures	Rounding	
*Age	Excavation Activities (e.g., grading, drilling, trenching, etc.)	Geologic Unit (e.g., Group, Formation, Member, etc.)	Carbonate minerals	
Fossil Type(s)	Level of effort: Full-Time or Part-Time	Stratigraphic Observations	Cementation	
Field Taxonomic Identification	Geologic Unit (e.g., Group, Formation, Member, etc.)	Lithologies	Bottom Contact	
Field Element Identification	Stratigraphic Observations	*Age	Sedimentary Structures	
In-Situ or Ex-Situ	Lithologies	Survey Area Sketch	Fossils	
Preservation Quality	*Age	*Associated Fossil Localities	Points Recorded	
Taphonomic Observations	Monitoring Area Sketch	*Associated Photographic Points	Start and Stop Points	
*Depositional Environment	*Associated Fossil Localities	*Associated Stratigraphic Points	Dip/Strike	
*Locality Dimensions	*Associated Photographic Points	Matrix Collected?		
Collected?	*Associated Stratigraphic Points	Field Recommendation s		
Locality Sketch	Matrix Collected?			

Preliminary Evaluation of Significance				
Field Recommendations				
Photograph Numbers				

Table 3. Phases of the fossil recovery process (locality evaluation to pre-curation) during field surveys versus construction monitoring.

Phase	Field Survey	Construction Monitoring
	Time is not usually a critical factor for all phases.	Time is usually a critical factor for all phases.
1. Preliminary Mitigation Evaluation - Is the locality worth exploring?	Initial examination indicates that fossil(s) are either possibly identifiable and meet pre-determined threshold criteria for scientific significance, or unidentifiable in which case locality should be recorded as 'not significant' and no further action is required (skip to Phase 3B).	Initial examination indicates that fossil(s) are either possibly identifiable and meet pre-determined threshold criteria for scientific significance, or unidentifiable in which case locality should be recorded as 'not significant' and no further action is required (skip to Phase 3B). Locality avoidance is not typically an option, even in the case of extensive fossil discoveries.
2. Locality Exploration - Is/are the fossil(s) worth collecting?	Determine areal extent of locality by surface prospecting and probing surface sediments with hand tools. Ant hills should also be explored. Unless necessary avoid the use of adhesives or consolidants and focus on exploration rather than stabilization or excavation. In cases in which partially exposed fossil(s) are determined to be 'not significant' following exploration, or can be avoided or collected later, skip to Phase 3B. Locality avoidance is typically an option for scientifically significant fossil localities.	Cordon of fossil locality if fossil(s) cannot be documented and recovered rapidly. Determine lateral and vertical extent of locality using hand tools, and if possible, in the case of larger localities, with heavy equipment. Unless necessary, avoid the use of adhesives or consolidants and focus on exploration rather than stabilization or excavation. If the fully explored fossil(s) are then determined to be 'not significant', skip to Phase 3B, and no further action is needed.
3. Locality Excavation, Collection, and Documentation	A. Collect fossil(s) from ground surface and if necessary, by quarrying. Use adhesives and consolidants as necessary. If the scope of work permits, collect samples for associated geochronology, paleomagnetic analysis, microfossil analysis, palynological analysis, isotope analysis, etc.. If budget and schedule permit, collect and wash test samples to determine whether the density of small fossils warrants bulk sampling. Collect bulk matrix samples (or ant hill gravel) if scientifically significant small fossils are present. B. Record locality as 'not significant' if fossil(s) discovered are found to lack	A. Collect unearthed fossil(s) by hand quarrying and/or with the assistance of heavy equipment if needed, appropriate, and applicable, from the ground surface or spoils piles. Use adhesives and consolidants as necessary. If the scope of work permits, collect samples for associated geochronology, paleomagnetic analysis, microfossil analysis, palynological analysis, isotope analysis, etc. If budget and schedule permit, collect and wash test matrix samples to determine whether the density of small fossils warrants bulk sampling. Collect bulk matrix samples (or ant hill gravel) if scientifically significant small fossils are present. Heavy equipment can be used to stockpile matrix away from construction

	scientific significance. For scientifically significant fossil(s), complete locality data recordation during surface collection and/or excavation phases, but prior to jacketing or packing and removal of fossil(s) from the locality. Additional mitigation recommendations could include collection if avoidance is not feasible or deferred collection pending approval. If the preferred mitigation is avoidance, survey and record an alternative corridor or project infrastructure location that avoids scientifically significant fossil localities.	activity. B. Record locality as 'not significant' if fossil(s) discovered were found to lack scientific significance. For scientifically significant fossil(s), complete locality data recordation during surface collection and/or excavation phases, but prior to jacketing or packing and removal of fossil(s) from the locality. Additional mitigation recommendations are usually not relevant to localities discovered during monitoring because such localities are typically graded away.
4. From the field to the repository	Transport fossil(s) from the field to the laboratory and from the laboratory to the repository (if different). Ensure that fossil(s) are properly packed and protected from damage and theft during transportation and storage. During transportation to the repository, ensure that proper documentation is available (permit, curation agreement, etc.).	Same as Field Surveys.
5. Laboratory Work	Fossil preparation, identification, and pre-curation work.	Same as Field Surveys.

Table 4. Standard Paleontological Resource Impact Mitigation Recommendations.

Clearance	If adverse impacts to scientifically significant fossils are anticipated to be non-existent or not significant for a given ground-disturbing project, a recommendation of paleontological clearance is typically appropriate.
Unpredicted Discovery Stipulations	In study areas or portions of study areas with low paleontological potential, including those for which a clearance recommendation has been made, unpredicted paleontological discoveries have occasionally been made by construction workers. Therefore, a clearance recommendation should be accompanied by a contingency for unpredicted discoveries which includes notification and evaluation procedures and pre-construction worker orientation.
Field Survey	If the results of an analysis of existing data indicate that there is a high potential for scientifically significant fossils to be present on the ground surface within a given study area, a pre-disturbance field survey should be recommended to document fossil localities within it and make further post survey recommendations (typically fossil recovery or avoidance).
Monitoring of Ground Disturbance	If the results of an analysis of existing data or field survey indicate that there is the potential for scientifically significant subsurface fossils to be adversely impacted by ground disturbance within a study area, monitoring should be recommended.
Fossil Specimen Recovery	If scientifically significant fossils are discovered during field surveys or monitoring of ground disturbance or are otherwise known to be present based on the results of an analysis of existing data and they are at risk of damage or destruction due to project disturbance, poaching, or vandalism, they should be collected and deposited in a repository. In general, and if possible, fossil collection is preferable to avoidance because it results in curation and permanent storage.
Avoidance	If the collection of scientifically significant fossils within a study area is not feasible due to size, abundance of resources, cost, and/or other factors, avoidance of a fossil locality by ground disturbing activity may be recommended, leaving the fossils intact in the field.
Matrix Sampling	Scientifically significant fossils of small or even microscopic size may be identified during field surveys or monitoring, or their presence may be tested for if they are not already known to be present in a given geographic area or geologic unit. A matrix sampling program may be recommended if tests indicate that scientifically significant fossils of small size are present, and it is determined that statistically valid samples can be obtained by collecting and processing larger samples of matrix.

Table 5. Scientific Significance Criteria. Fossils are considered scientifically significant if one or more of these five criteria are met (from Scott and Springer, 2003).

1. The fossils provide data on the evolutionary relationships and developmental trends among organisms, both living and extinct.
2. The fossils provide data useful in determining the age(s) of the rock unit or sedimentary stratum, including data important in determining the depositional history of the region and the timing of geologic events therein.
3. The fossils provide data regarding the development of biological communities or interaction between paleobotanical and paleozoological biotas.
4. The fossils demonstrate unusual or spectacular circumstances in the history of life.
5. The fossils are in short supply and/or in danger of being depleted or destroyed by the elements, vandalism, or commercial exploitation, and are not found in other geographic locations.

Table 6. General types and typical minimum content of mitigation paleontology reports.

Paleontological Resource Impact Evaluation Report	**Paleontological Field Survey Report**	**Paleontological Monitoring Report**	**Paleontological Resource Impact Mitigation Plan**	**Environmental planning documents**
Summary and/or Introduction	Summary and/or Introduction	Summary and/or Introduction	Introduction	Existing Conditions/Affected Environment
Methods	Methods	Methods	Methods	Environmental Consequences/ Impact Analysis
Laws, Regulations, Ordinances, Policies, and Standards	Laws, Regulations, Ordinances, Policies, and Standards	Laws, Regulations, Ordinances, Policies, and Standards	Laws, Regulations, Ordinances, Policies, and Standards	Mitigation Measures
Project requirements	Project requirements	Project requirements	Project requirements	References
Museum/agency Records Search Results (follow SVP 2016[1] where applicable)	[2]Museum/agency Records Search Results	[2]Museum/agency Records Search Results	[2]Museum/agency Records Search Results	Administrative Record
Geologic Map and Aerial Image Review and Literature Search Results	[2]Geologic Map and Aerial Image Review and Literature Search Results	[2]Geologic Map and Aerial Image Review and Literature Search Results	[2]Geologic Map and Aerial Image Review and Literature Search Results	
Project Theoretical Framework	[2]Project Theoretical Framework	[2]Project Theoretical Framework	Project Theoretical Framework	
			Monitoring Methods and Procedures	
			Impact Mitigation Methods and Procedures	
	[2]Field Survey Results including all fossils discovered and their scientific significance	[2]Field Survey Results	[2]Field Survey Results	
		Monitoring and Mitigation		

		Results (stratigraphy and fossils recovered, if any)		
Mitigation Recommendations	Mitigation Recommendations	Recommendations for Future Work	Recommended Monitoring Locations and level of effort (may need full version in an Appendix)	
			Additional Pre-construction tasks	
References	References	References	References	
	Appendix: Documentation of Areas Surveyed	Appendix: Documentation of Areas Monitored		
	Confidential Appendix: Fossil Locality Data	Confidential Appendix: Fossil Locality Data	Confidential Appendix: Fossil Localities Discovered During Pre-construction field surveys	
	Appendix: Receipt of Fossil(s) from Repository	Appendix: Receipt of Fossil(s) from Repository		
	Appendix: Permit(s)	Appendix: Permit(s)		

[1]SVP's Best Practices Guidelines for Repositing and Disseminating Contextual Data Associated with Vertebrate Fossils (https://vertpaleo.org/wp-content/uploads/2021/01/SVP-Paleo-Best-Practice-Guidlines-2nd-Ed.pdf).

[2]If already completed for an earlier report for the same project or study area, cite earlier reports.